Static magnetic response of multicore particles

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Here we present theoretical calculations [1] of the characteristics of the static magnetic response of multicore magnetic particles. A distinctive feature of these particles is that they contain a considerable number ($\sim 10^2$) of nano-sized inclusions, representing magnetic single-domain nano-crystallites. We model these “cores” as uniformly magnetized spheres with uniaxial magneto-crystalline anisotropy, the energetic barrier of which is comparable with the thermal energy. So the nano-crystallite magnetic moment is not blocked, and thermal fluctuations result in the stochastic reorientation of the magnetic moment inside the crystallite. It means that we consider the model of a multicore magnetic particle as an ensemble of superparamagnetic nanoparticles, the position and the easy magnetization axis of which are fixed in some random arrays. Here the magnetic moments of a multicore particle are induced by an external magnetic field. The essential point is that the magnetic response of a multicore particle is dictated by the internal rotation of the magnetic moment within each nano-crystallite.

We calculate the field dependence of the crystallite magnetic moment for randomly given directions of the easy axis and arbitrary values of the magneto-crystalline energy barrier. Summing up the field-directed components of the core magnetic moments, we get the magnetic moment of the multicore particles under the assumption that that magnetic inter-crystallite interaction can be neglected. An important effect is observed here: the weak-field magnetic response of a multicore particle turns out to be independent of the anisotropy energy due to random orientations of the core easy axes.

Our theoretical analysis results in simple expressions for the multicore particle magnetic susceptibility, which can be effectively used for processing experimental data [2] and estimating the magnetic characteristics of multicore particles and their suspensions.

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